Integrated Process Risk Management (IPRM)

for Refineries and Petrochemical Complexes

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Why IPRM is needed?

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- This is where IPRM tools can play a very important role to integrate the human knowledge & experience with actual statistical data & mathematical models in order to simplify, prioritize and optimize the decision making process.

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- ❖ Who would be interested in the IPRM toolbox?
  - Plant managers
  - Insurance companies
  - Investors
  - Environmental and Safety Regulators or Commissioners

IPRM Outputs

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- Quantify risks associated with equipment failures in different processes. **Determine the significance** of the failures in term of production losses ($).
- **Prioritize maintenance** activities, and plant modifications in different processes and units for different equipment.
- **Optimize the frequency** of inspections and equipment testing.

How is IPRM model developed?

IPRM Inputs

Plant Design Documents and Drawings

(PFDs and P&IDs)

+

Operational and Maintenance Data

(Process Engineers & Maintenance Staff

Historical Data, Work Orders, Human Errors

Failure Events, Event Durations & Frequencies)

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3. Classifying failures into certain production loss categories (e.g., 10%, 50% or 100% production losses). These inputs are obtained from process engineers and operators.

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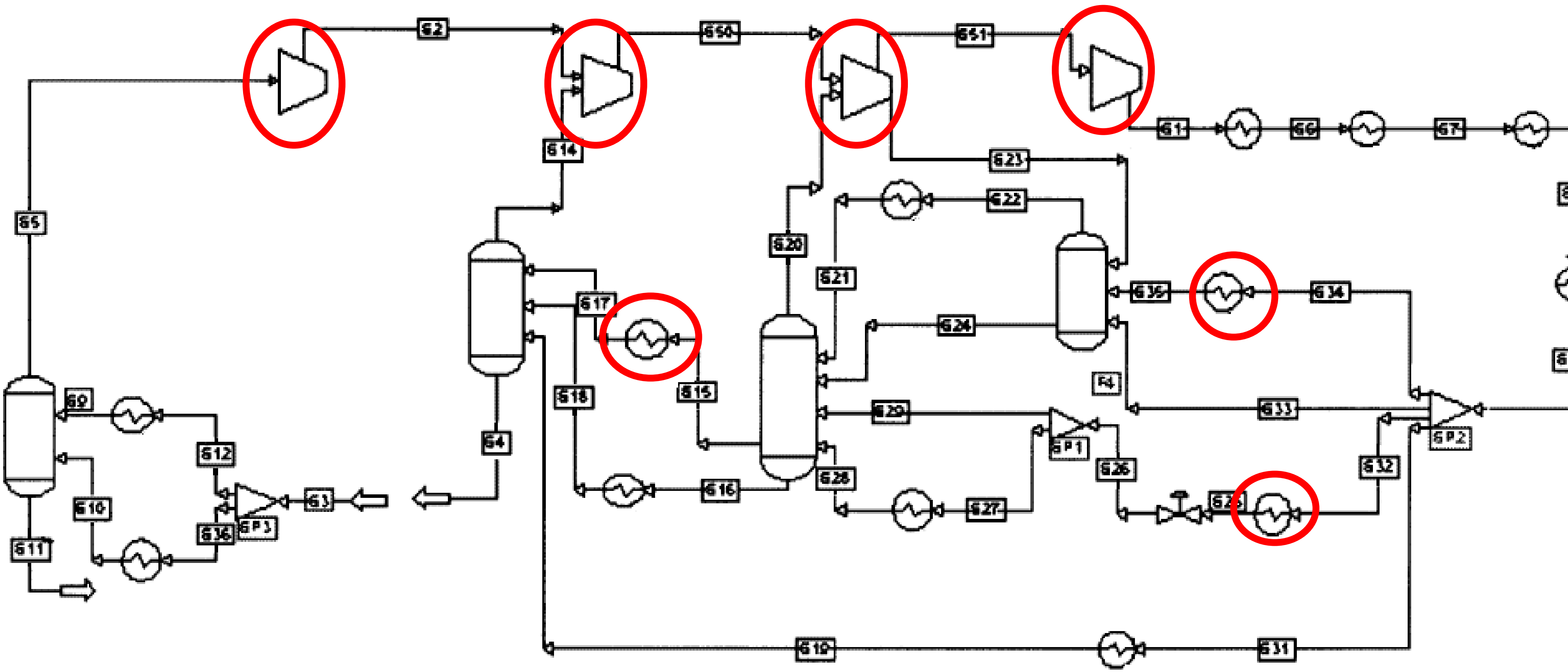
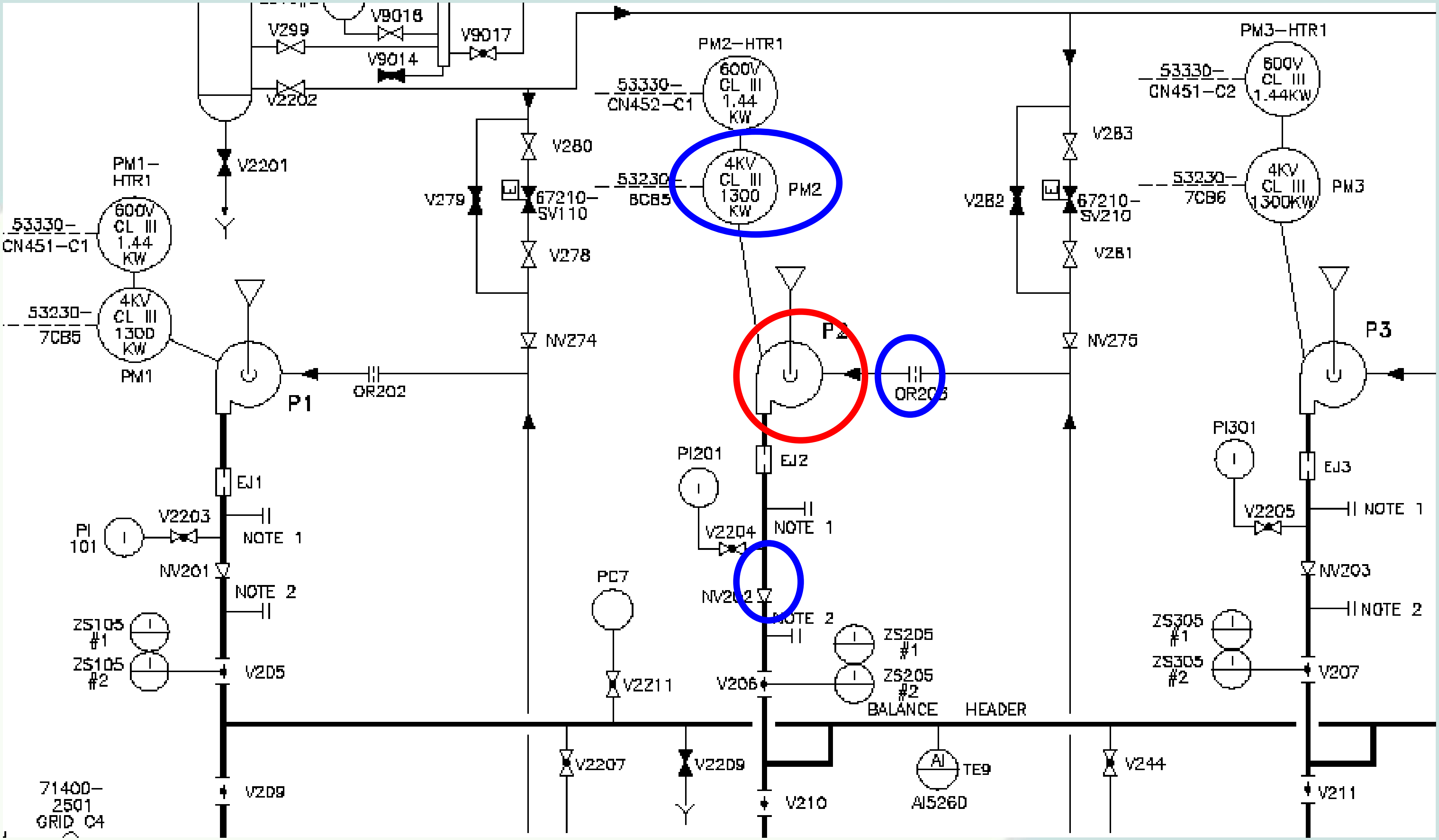
6. and finally, summarizing everything in a table, so that a fault-tree model can be produced.

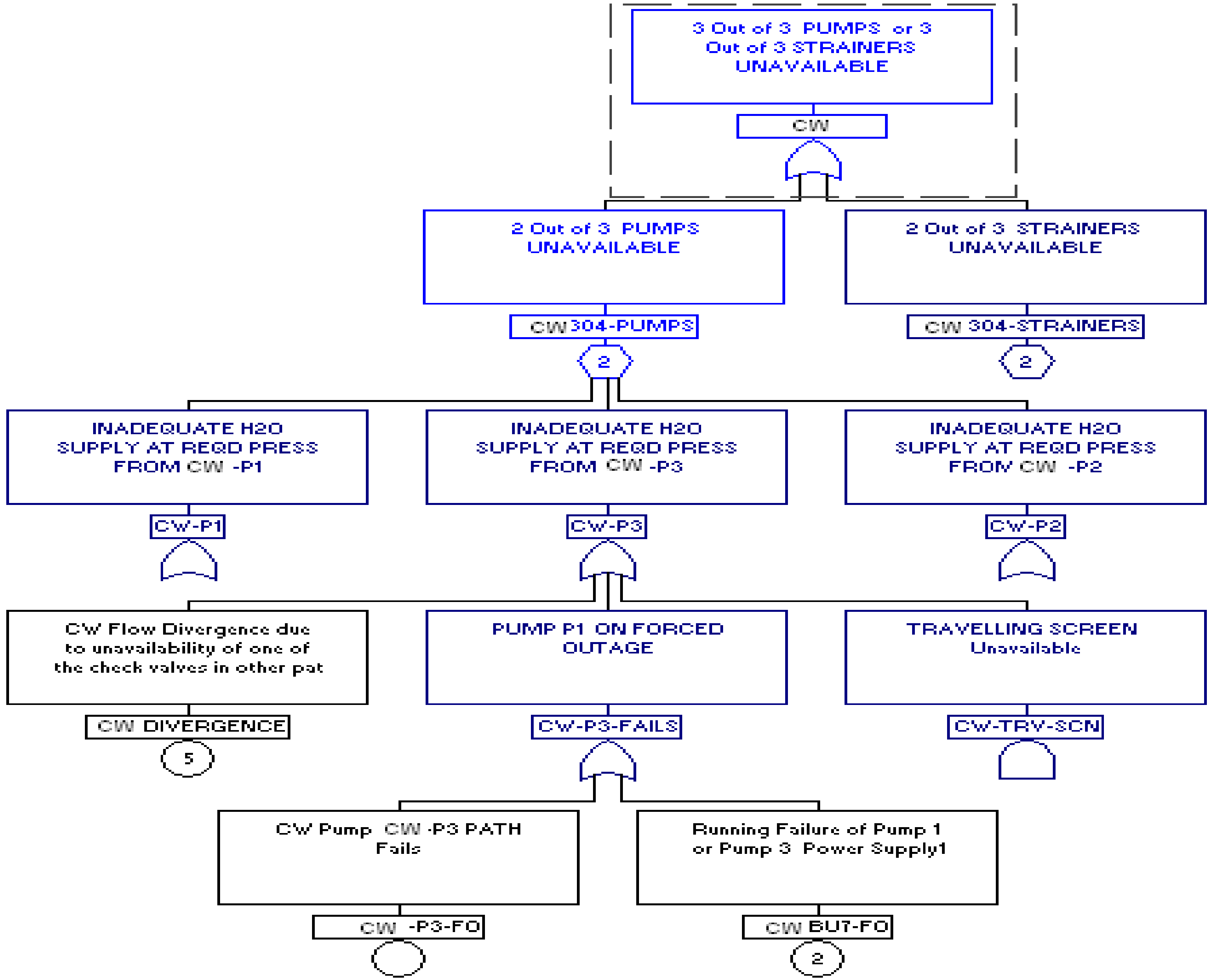
Modeling Procedure: Start with the PFD of each process unit.



Modeling Procedure: From PFD to more detailed drawings (e.g., P&ID)



Modeling Procedure: From P&ID to Fault-Tree Diagram (Boolean algebra)



Modeling Procedure: From Fault-Tree Diagram to MS Excel Spreadsheet

Frequency (occr/yr)	Event1	Event2	Event3	Durations (hrs)	Production Loss Ratio	Unit Capacity (liter/hrs)	Production Loss (liter/yr)
1.00E-02	CW-PV501-FO			50	1	333,333	2.E+05
1.00E-02	CW-PV501-HE			50	1	333,333	2.E+05
1.00E-03	L-FF			12	1	333,333	4.E+03
2.80E-04	DIVERGENCE	LAKE-TMP-H		12	1	333,333	1.E+03
2.80E-04	DIVERGENCE	LAKE-TMP-L		12	1	333,333	1.E+03
2.40E-04	BU7-FO	LAKE-TMP-VH		12	1	333,333	1.E+03
1.86E-04	DIVERGENCE	LAKE-TMP-VH		12	1	333,333	7.E+02
1.86E-04	DIVERGENCE	LAKE-TMP-VL		12	1	333,333	7.E+02
3.60E-04	BU7-FO	LAKE-TMP-H		12	0.4	333,333	6.E+02
3.60E-04	BU7-FO	LAKE-TMP-L		12	0.4	333,333	6.E+02
2.80E-04	DIVERGENCE	LAKE-TMP-H		12	0.4	333,333	4.E+02
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2.50E-04	CW-GA1-SO	SUMMER		12	0.4	333,333	4.E+02
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7.36E-05	MCC451-UV	CW-SC2-FO	LAKE-TMP-H	12	1	333,333	3.E+02
7.36E-05	MCC451-UV	CW-SC2-FO	LAKE-TMP-L	12	1	333,333	3.E+02
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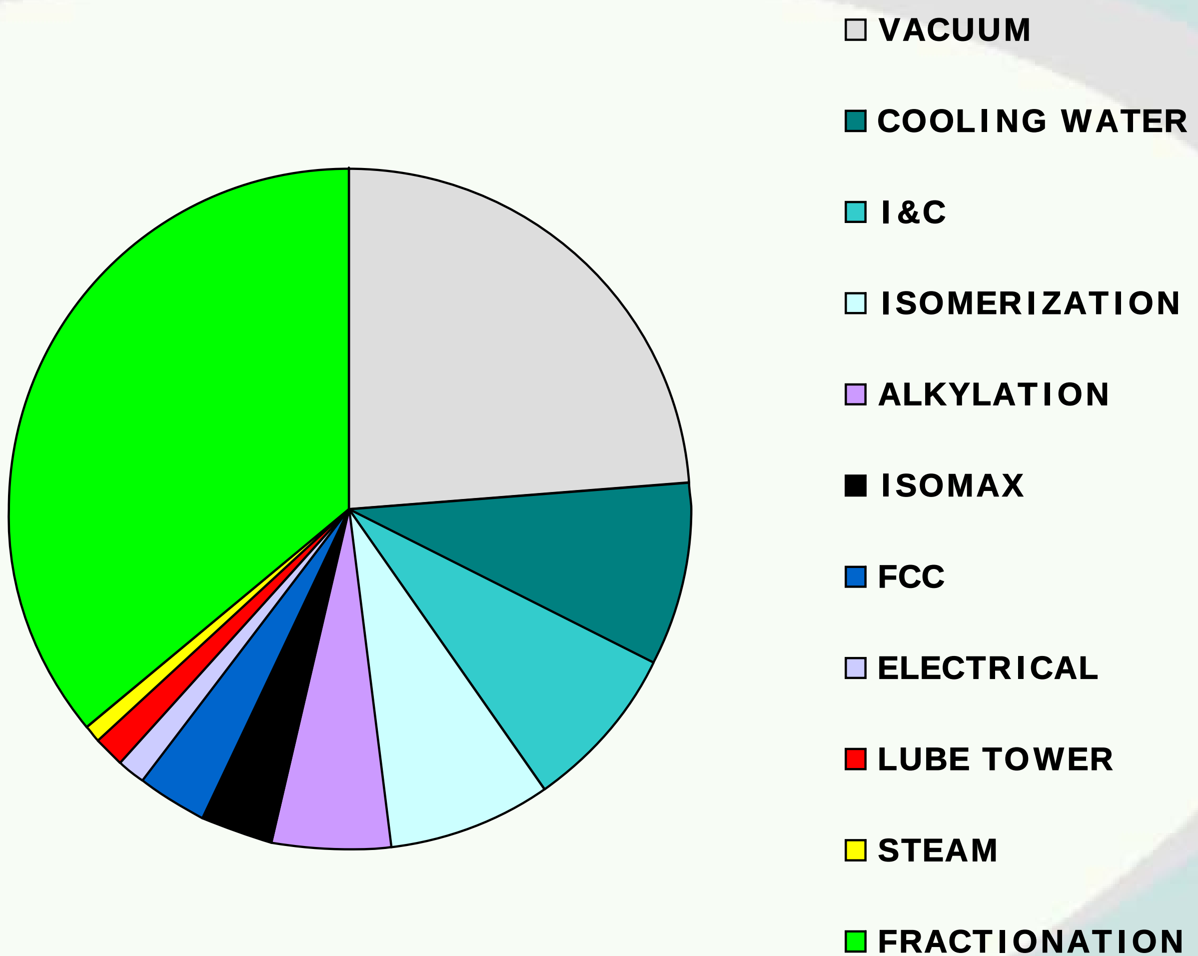
Some of the main processes in a typical refinery are:

- Fractionation (atmospheric & vacuum distillation)
- Fluidized Catalytic Cracking
- Hydrocracking
- Alkylation
- Isomerization
- Reforming
- Extraction
- Dewaxing
- MTBE unit

IPRM Output

Process Significance Ranking



Maintenance Optimization

in

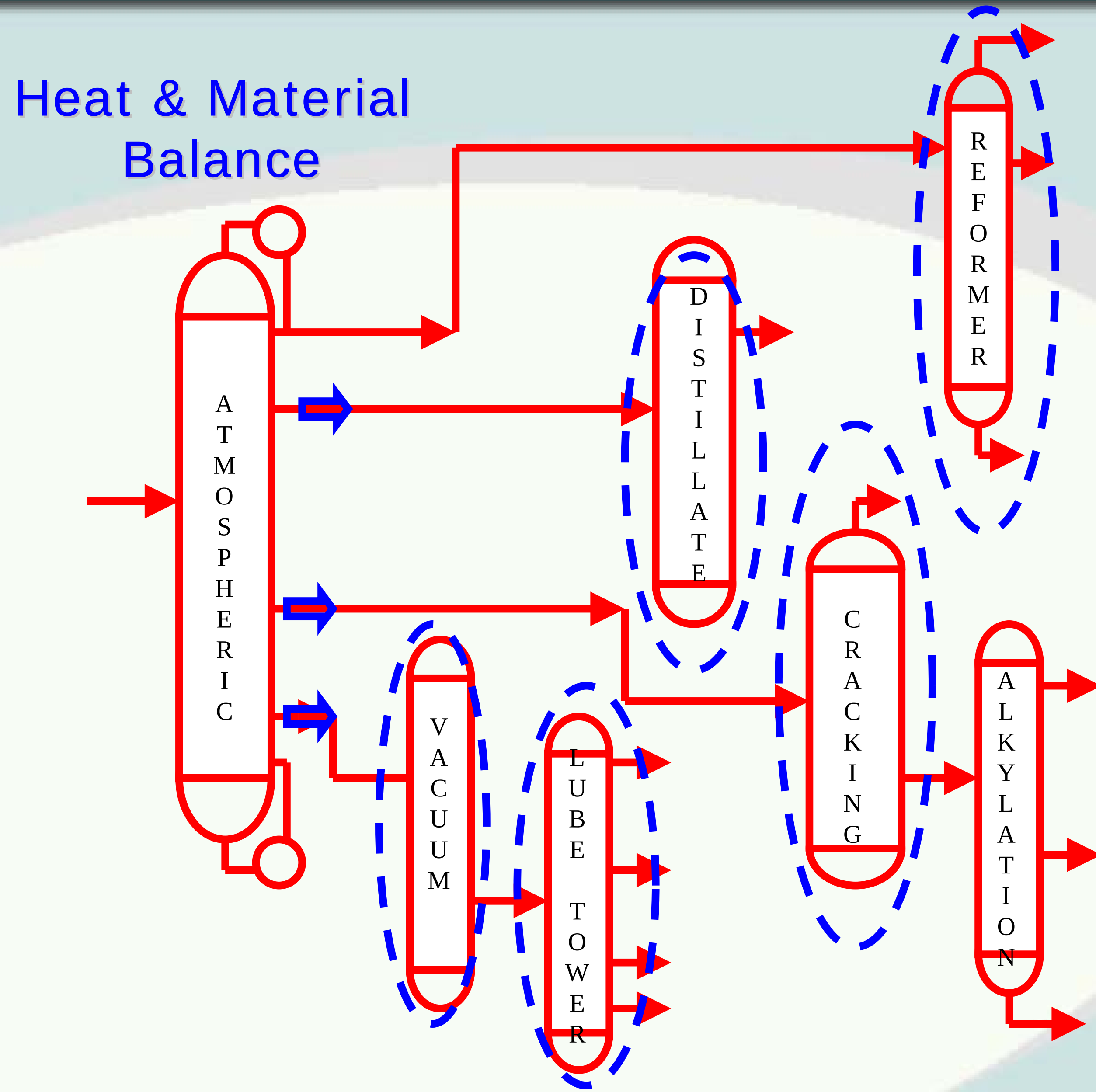
Cooling Water Supply System of a 50,000 BPD Refinery

Problem Definition

With $50K budget, and known history of problems in Cooling Water system:

Where should the money be spent to maximize the reliability of the cooling water supply system?

Cooling Water Supply System in a Refinery



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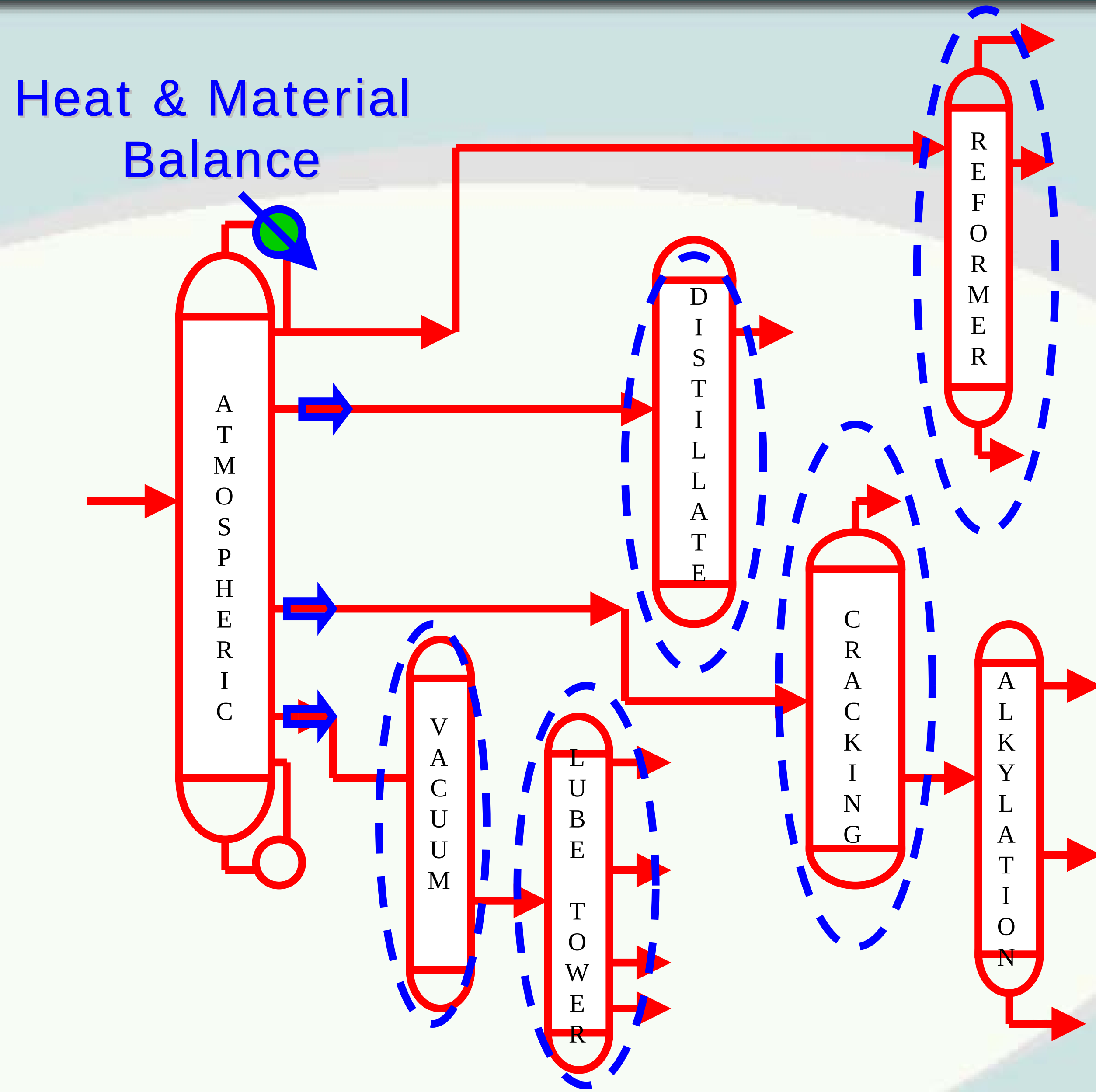

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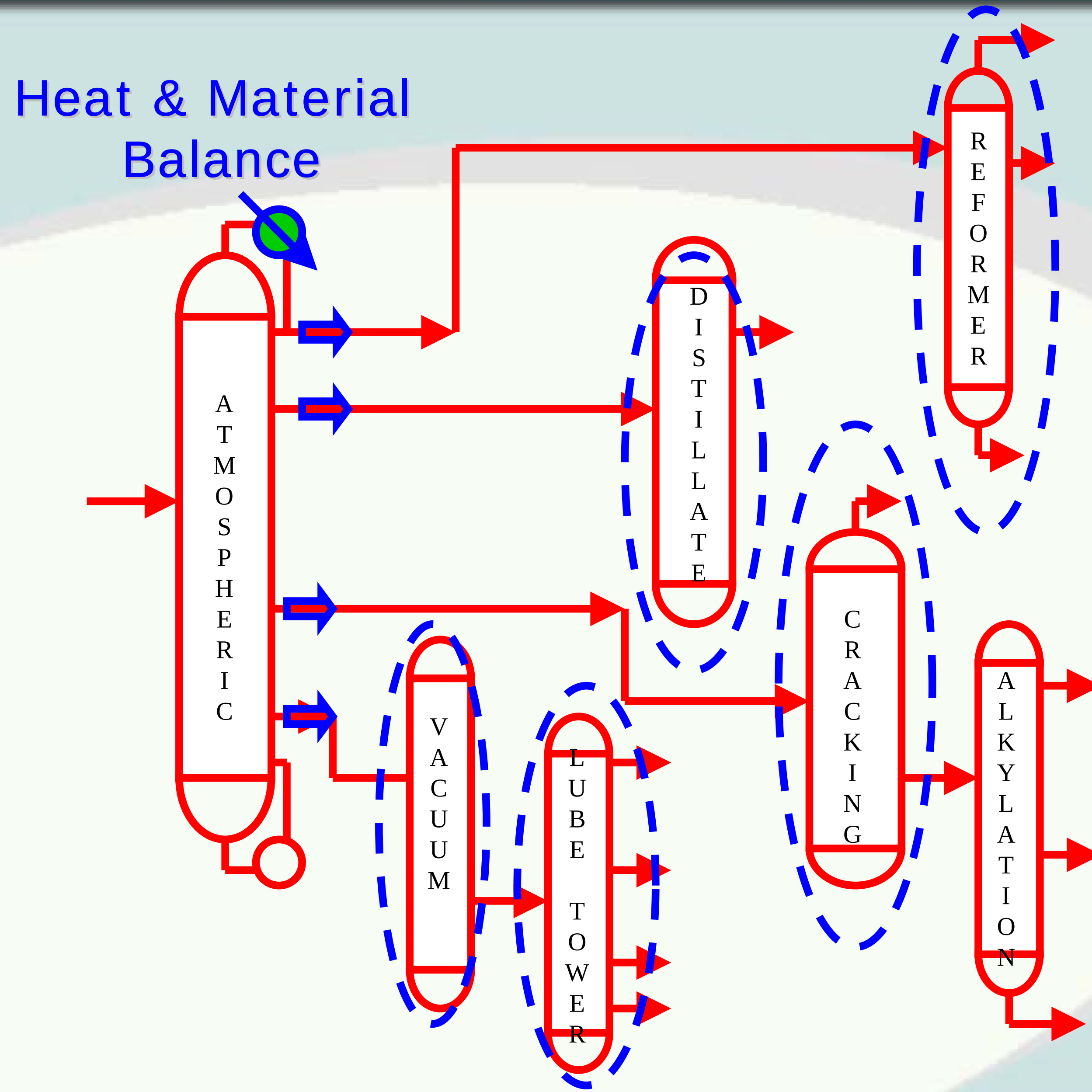

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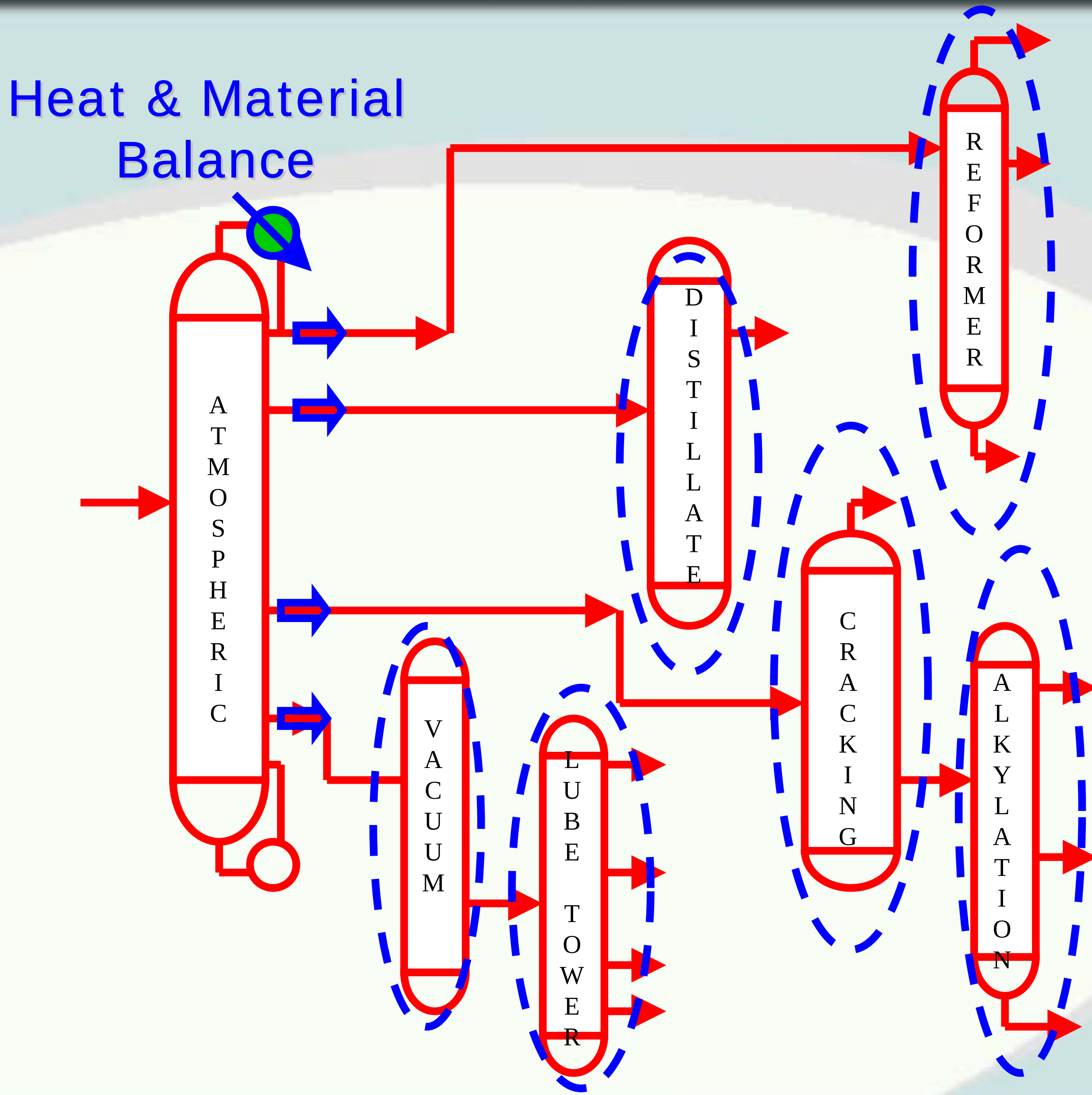

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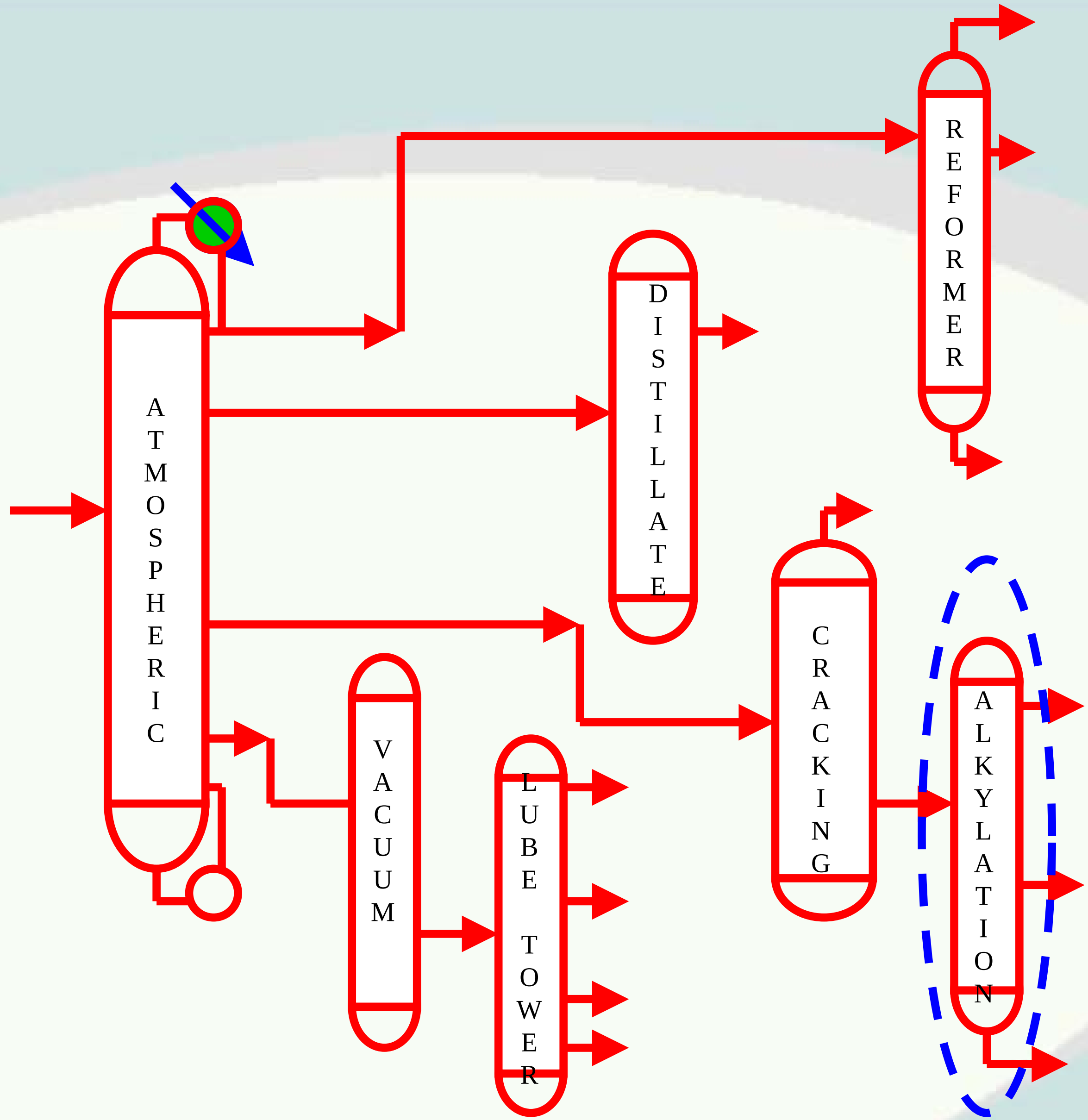
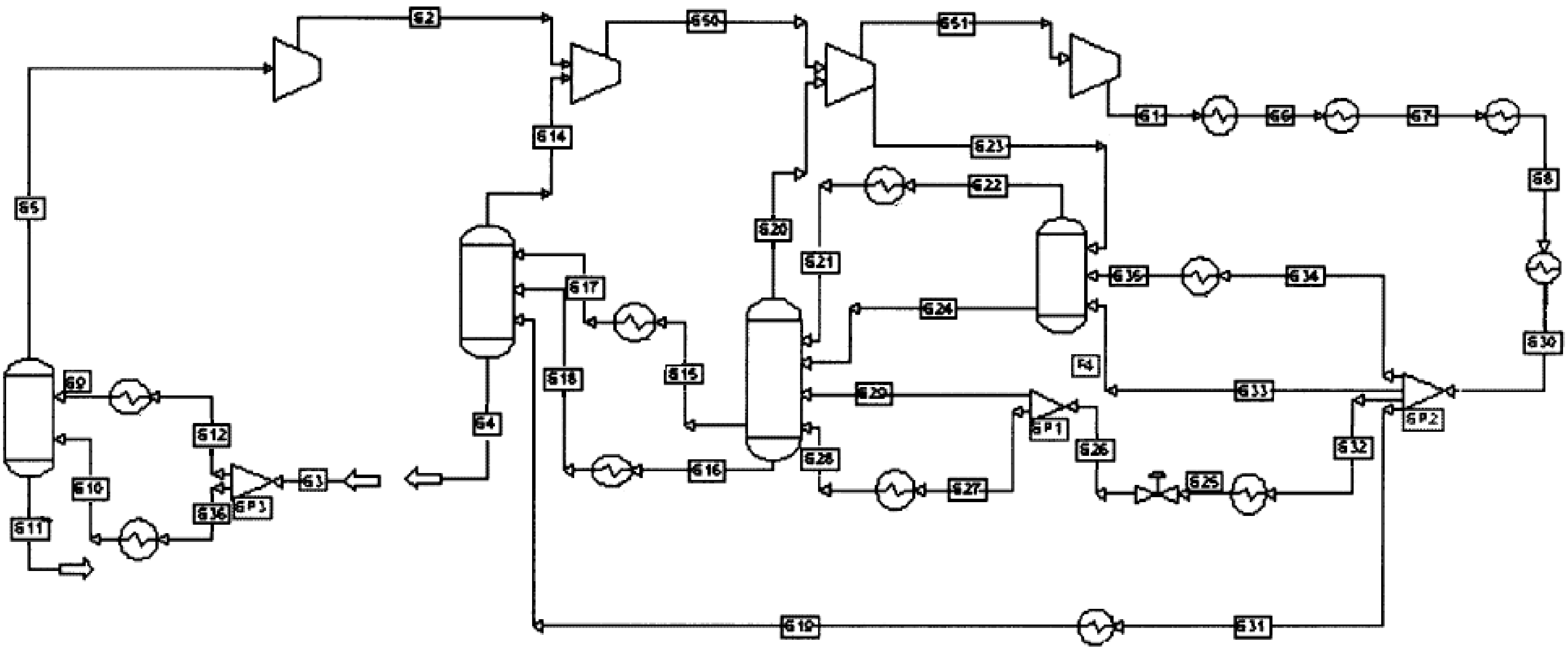


Cooling Water Supply System in each process unit



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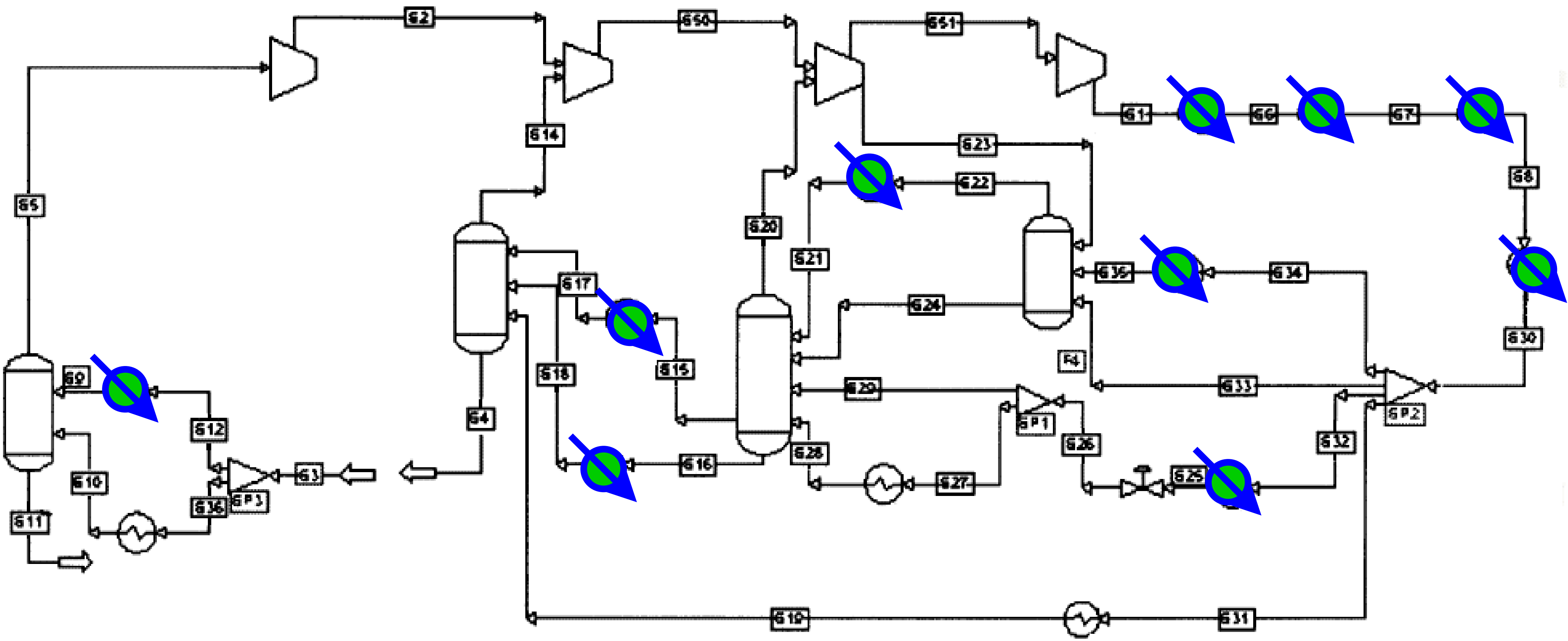

Maintenance Optimization and Design Prioritization

Adding a new standby cooling water supply pump for summer heat peaks?

OR

Adding a valve for cooling water supply to the fractionation main condenser?

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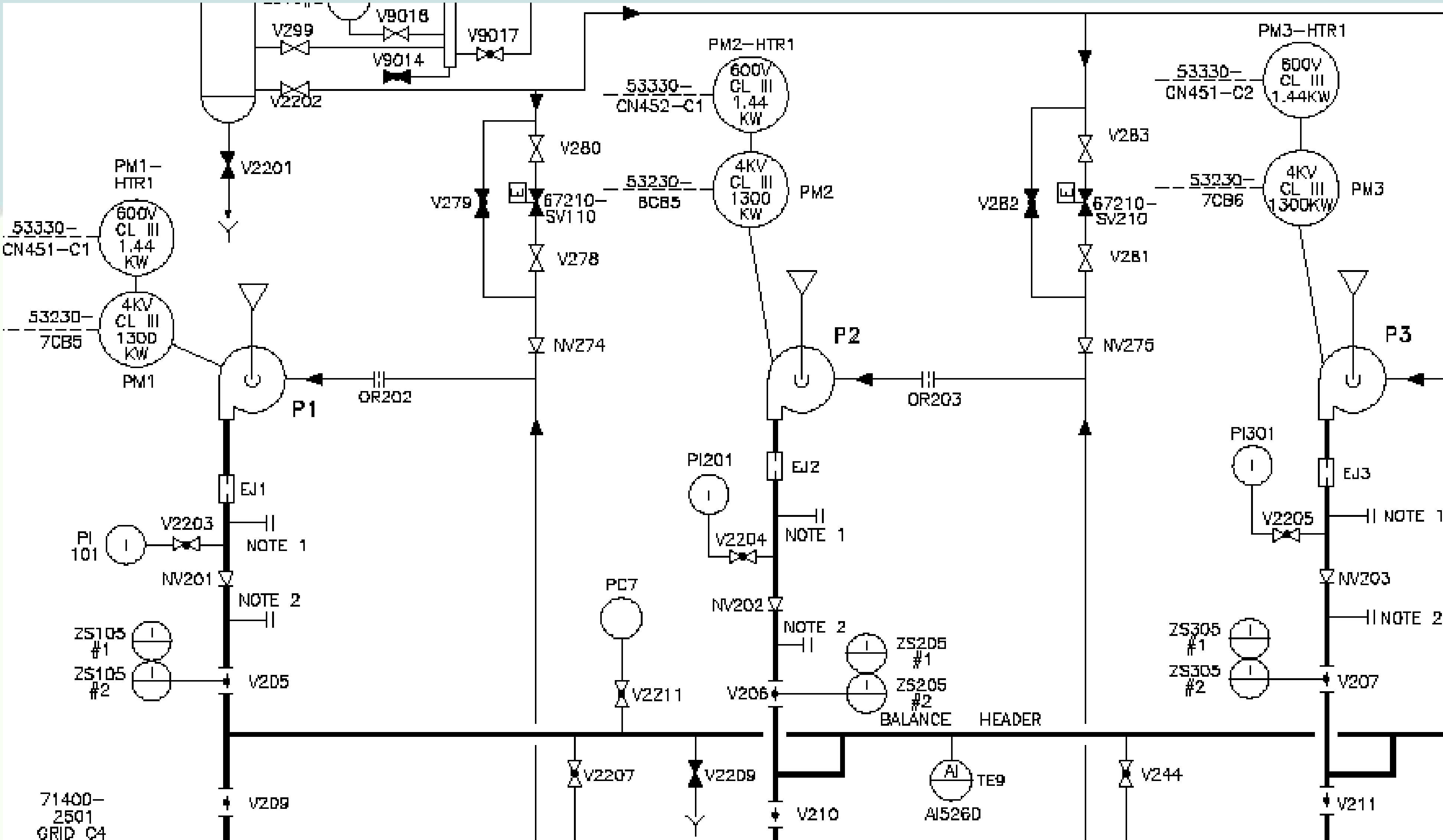

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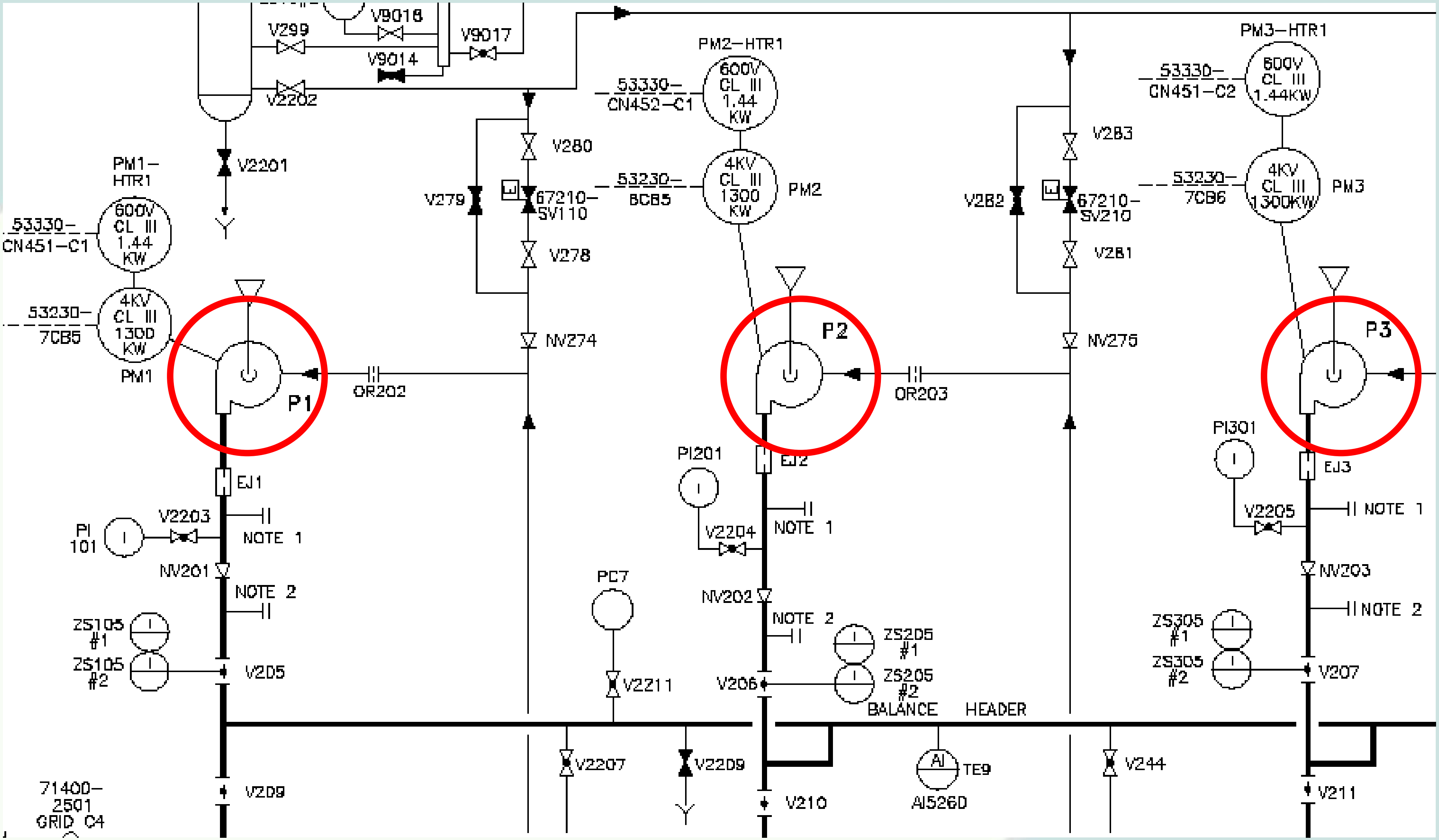

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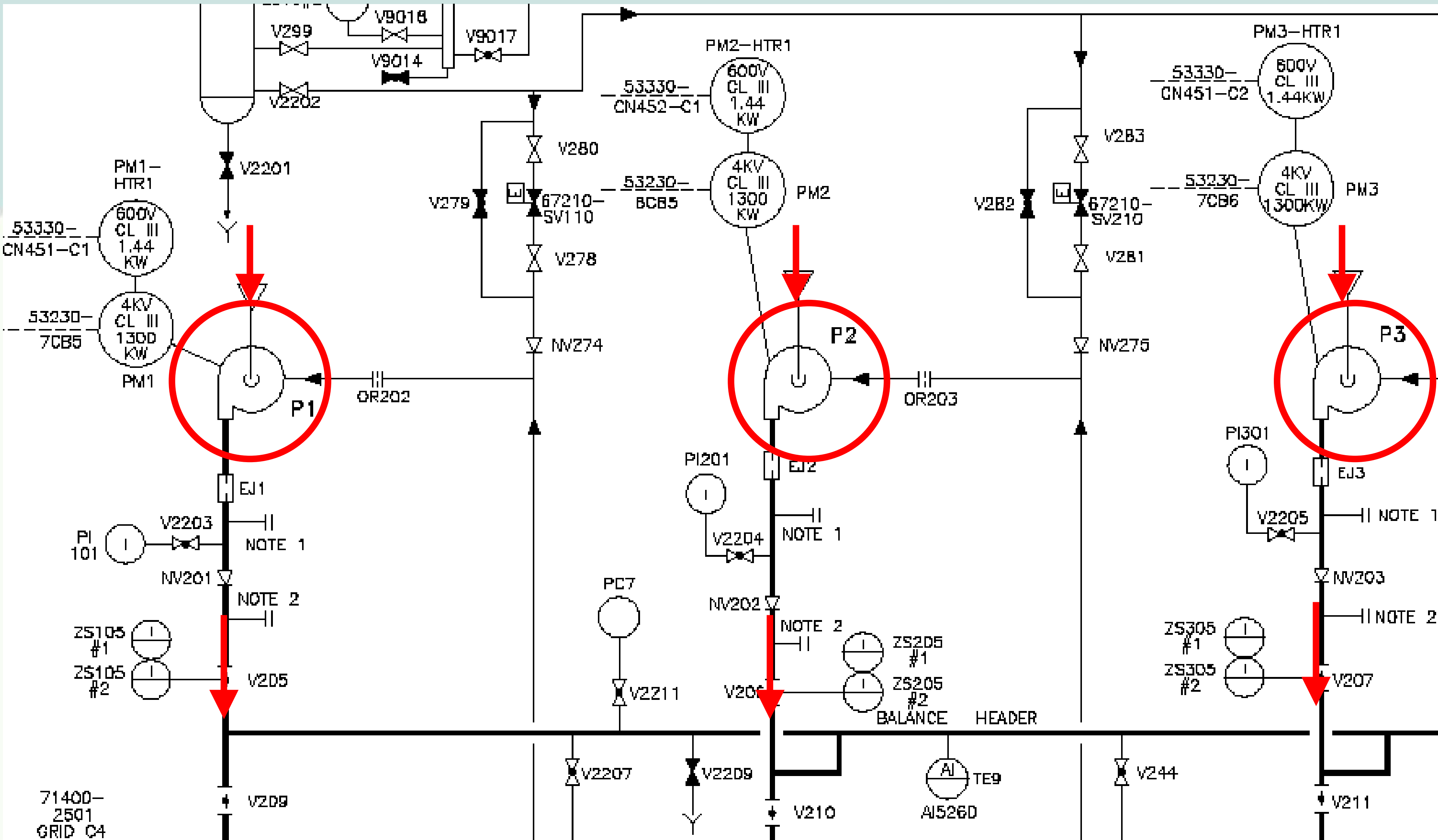

Fractionation Heatexchanger

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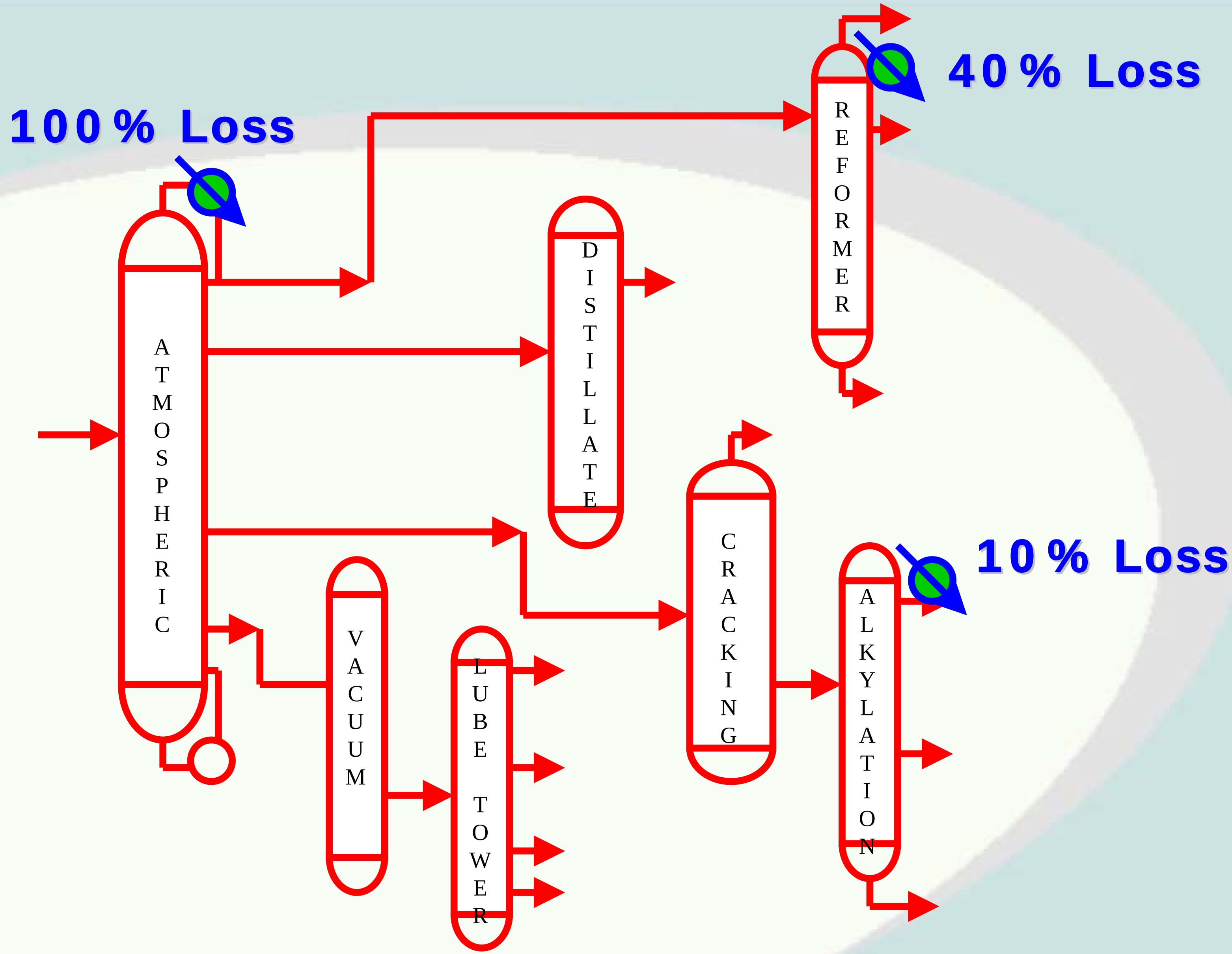
- Trip of **two** (2/3) of the pumps in summer, forces the plant to be shutdown (i.e., 100% loss).

Cooling Water Supply System



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As a result, the conclusion could be different.

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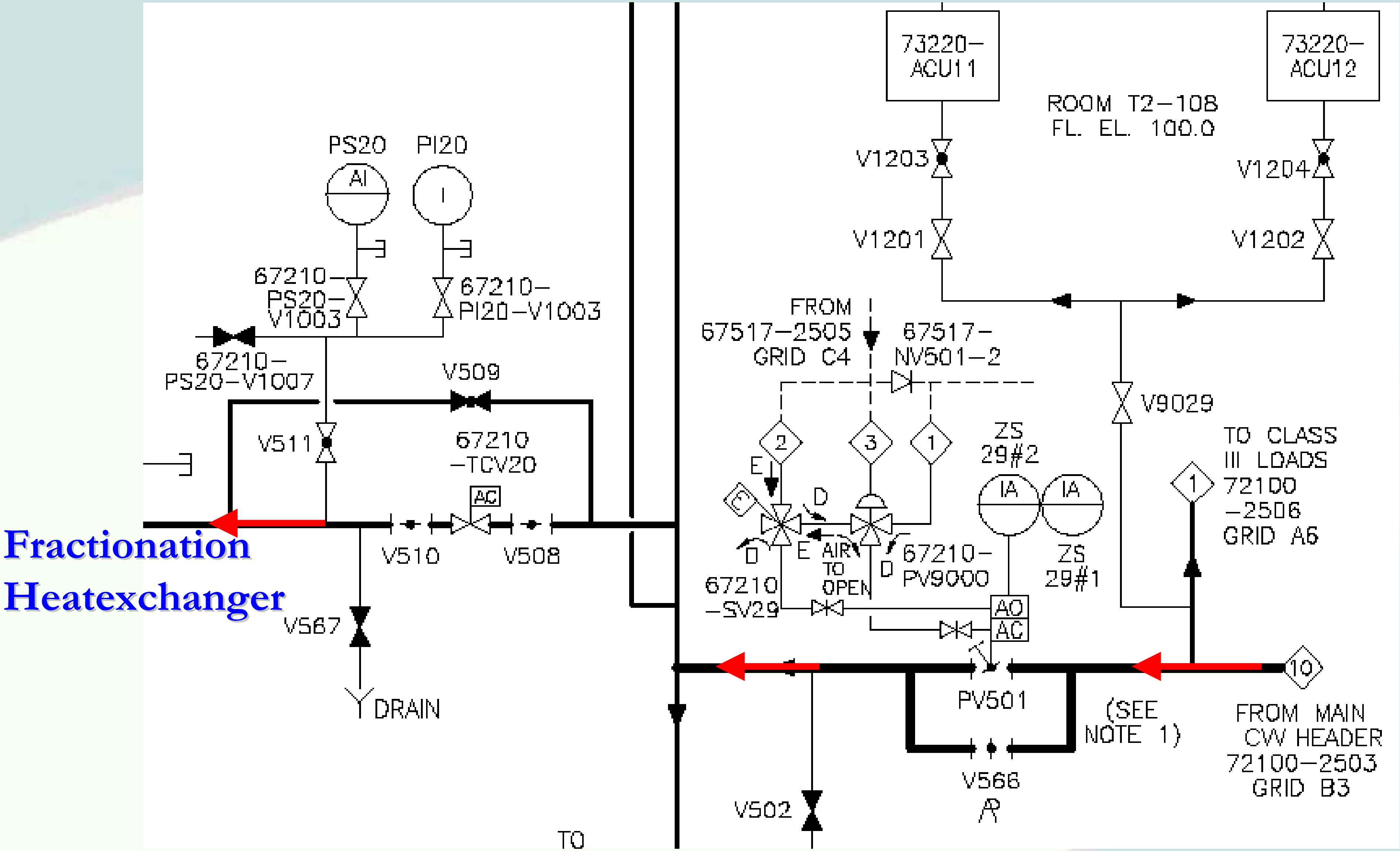

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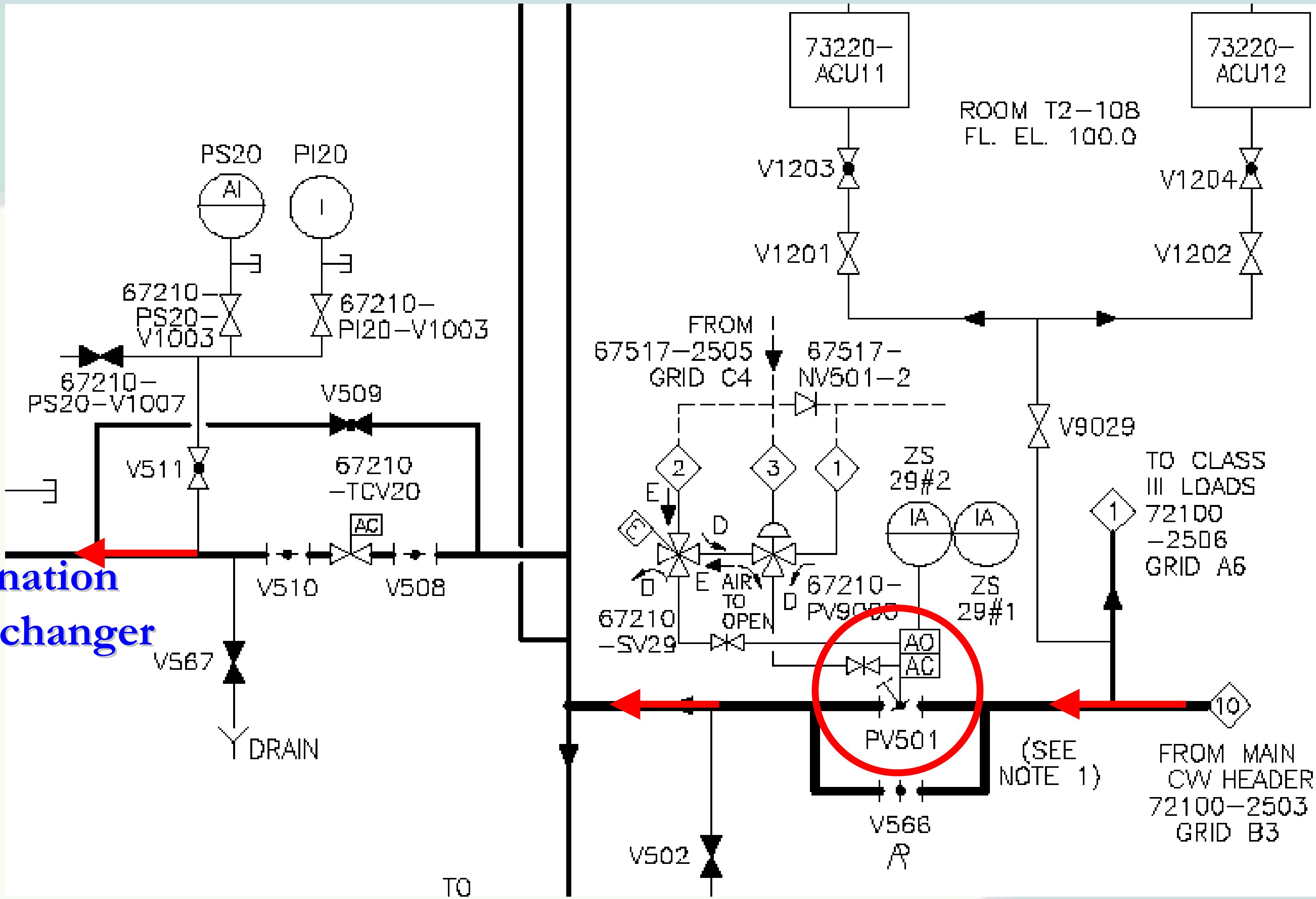

Fractionation Heatexchanger

Adding a 2nd valve parallel to the existing CW supply valve (PV501)

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The most important sequences of events?

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Create a new version of the IPRM model with two valves in parallel, and compare with the baseline.

REDUCED RISK> 350,000 lit/yr (loss before)-23,000 lit/yr (loss after modification) x $0.1/lit (net-profit)= $33,000 profit loss prevented/yr

MODIFICATION COSTS> $50,000 investment.

2yrs ROI; Implement this modification as soon as possible √

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- The IPRM model is different than process simulation. It is much simpler and quicker than process simulation.
- The results are plant specific and should be updated with new operating experience every few years, and after any change in process design.
- The model maintenance is very simple and straightforward.

Thank You

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- Additional preventive maintenance, upgrading pumps, or gland-seals would reduce the failure frequency from **0.01 trips/yr to 0.001 trips/yr**
- Additional preventive maintenance would cost $3,000/yr
- The new ROI would be **25yrs**. Still you may decide against the additional maintenance, and allocate the existing resources to other equipment.